Dr. Ballard's Report to the Local Government Board on an unusual Prevalence of Enteric Fever at Ascot during a Period of Four Years and a half.

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To the north of the Ascot Station of the South-Western railway, running in a westerly direction from London to Reading, is a ridge of hill, about a mile long from east to west, near the summit of which to the west is the grand stand of the Ascot racecourse, and a little further westward the Royal Ascot hotel. From this hotel the main road to London runs eastward, passing the grand stand, the groups of houses forming what may be regarded as the village of Ascot, and then, further eastward, passing through the northern extremity of the village of Sunninghill. In various houses situated on both sides of this road for a distance of about 2½ miles eastward of the Ascot hotel, and in houses situated in roads and lanes passing off north and south from it at Ascot and Sunninghill, there have occurred yearly, since the middle of the year 1873, numerous cases of enteric fever; and, in addition, several persons who had been residing or visiting in houses along these roads suffered attacks of the same fever shortly after their return to London or to their own houses. This fact was represented to the Board in June last year, and I was instructed to make an inquiry into the cause of the epidemic. The cause suggested by a lady resident at Ascot, who had taken great pains to discover the names and residences of those attacked, and the source of their habitual milk supply, was that the epidemic was spread by the supply of milk from one particular dairy farm in the neighbourhood. The *primâ facie* case against this milk supply was a strong one, inasmuch as it appeared from that lady's statement that the greater part of the families invaded had been supplied with milk from that farm. Dr. Woodforde, the Medical Officer of Health of the Berkshire combined sanitary district, who instituted an inquiry into the epidemic in 1876, and reported briefly upon it to the Rural Sanitary Authority, could not accept this explanation. His inquiry, however, was (probably on account of the other calls upon his time and the lack of facilities) less complete than that which it has been possible for me to carry out with his assistance, and that of Mr. Byrne, the Inspector of Nuisances. I am indebted to both of them for much help.

In order properly to represent the case, it will be necessary first to present some general notion of the contour of the epidemic district. The Ascot hotel stands at an elevation of 309 feet above Ordnance datum, and the main road running nearly along the ridge of hill, or a little to the northward of it, sinks on the whole from that spot more than 100 feet to the village of Sunninghill, about 1½ miles to the eastward. In this course there is a steep slope from the summit of the ridge southward to Sunninghill bog, and another more gradual slope northwards across the racecourse towards Winkfield and towards the road leading from Ascot to Winkfield on the north-eastern side of the racecourse. The steepness of the fall from the main road to the bog on the south side (along which the railway runs on an embankment), may be judged of by the fact that the station road leaves the main road at Ascot at an elevation of about 281 feet, and that the bench mark on the station, about 530 yards from that spot, is 227 feet, and this is much higher than the actual level of the bog. A portion of the village of Sunninghill lies on the southern declivity.

Along both sides of the main road, but chiefly on its south side, plots of land have been taken up for the erection of villa residences, which stand away from the road severally in their own private grounds. Most of these residences are large, few of them can be regarded as small. At the village of Ascot, near where the road to the station passes off from the main road, there are on the north side of the main road and in a lane (which having no name I here designate for convenience and reference "Racecourse Lane,") and road "New Mile Lane" (the road to Winkfield), passing off northward from it some houses of the middle class, shops, and cottages, the last occupied by persons of the labouring class. Other similar houses mainly constitute the village of Sunninghill. The villa residences are commonly filled with visitors during the race week (in the middle of June), and some of them are habitually let furnished, or lent to visitors for the summer season, being occupied in other parts of

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the year by their owners. The middle-class houses also sometimes receive lodgers for the summer, and so, during the race week, do the houses of the cottage class. It will be understood, therefore, that the inhabitants of the epidemic district comprise families belonging to all grades of society, from the upper to the lowest, or almost the lowest.

In making observations upon the geological peculiarities of the district, I have had (with the kind permission of the authorities of the Survey) the assistance of Mr. C. E. Hawkins, one of the staff of the Geological Survey. In the Appendix to this Report I have given the measurements of the depths of the wells examined, and two sections made by Mr. Hawkins, showing their relation to the surface of the ground.

The geological formation on which the district stands is the Lower Bagshot sand, which lies immediately upon the London clay. In various parts upon the surface there are beds of gravel of a few feet in thickness, and in some places, either upon the surface in patches or at various depths below the surface, there are layers of a pale yellow sandy clay and occasional seams of nearly pure pipeclay. These clay layers of varying thickness and extent are irregularly dispersed through the sand, together with more or less of a sandy loam. On sinking down through the ground, water is met with abundantly in a "running sand," at depths, varying with the elevation of the place, from about 70 to 16 feet. It is found impracticable to sink wells many feet in this "running sand"; and, when the attempt has been made, the wells have quickly silted up and sand has been pumped up with the water. It is into sand of this character that nearly all the wells which furnish the water supply of the district are sunk. Whether this water is held up by the London clay beneath or by some of the subordinate clay layers alluded to above, is a matter I have not been able to determine. On the whole the level of the water in the wells varies with the level of the surface of the ground, but there are exceptions which seem to indicate that the water of some of the wells is held up by a different and more superficial clay layer to that which holds up other and deeper wells. One reason leading me to think that there are such more superficial layers of water is, that in some parts, both at the top of the ridge and along the southern slopes, there are springs and wells which are said never to be dry, in which water is found, not a little above the general watershed in the sands, but greatly above that level, and these wells have a considerable depth of water in them.

During a period of over 40 years, during which Mr. W. B. Brown has carried on the principal medical practice at Ascot, he informs me that no similar epidemic of enteric fever to that which this inquiry refers to has ever occurred. Now and then, but rarely, he has met with cases in his practice, but the fever has never spread beyond the family invaded. In the middle of 1873, at the very time that the outbreak in Marylebone, which was traced to the milk supply of a particular dairy, was in progress, three cases of enteric fever occurred almost simultaneously on the top of the ridge of hill on which the village of Ascot stands. All three cases occurred in persons who had recently been in London, and in the part of London within the area of that supply. The first of these three persons was a son of the Hon. A. P. He was a boy aged about 10 years. He was staying at Mr. P.'s house, "Heatherfield," nearly opposite the Ascot Hotel, but came to his father's house in London, it is believed on July 2, (but it might have been at a somewhat later date,) stopping there two days to attend some parties. He was taken ill on July 23, and passed through the disease at the house at Ascot. No one else at the house in Ascot or in London was attacked. The second was the son of Mr. C., aged nine years. The occurrence of this and other cases of fever in the same family, is on the notes of the inquiry made into the Marylebone epidemic by Mr. Netten Ratcliffe and Mr. Power. This boy went from his home in London to Ascot Wood House on July 23, and he was taken ill with fever on August 3, and passed through the disease at that house. The third case was that of a housemaid at a house called "Firbank," on the opposite side of the main road, and about 900 yards to the eastward the last-named house. This young woman visited London on July 29, stopped the night with her sister who was in lodgings at North End, Fulham, visited a friend in Grosvenor Street within the Marylebone epidemic district, and returned to Ascot the next day. She was taken ill on August 10, and passed through the disease at Firbank.

The three above cases occurred in persons who had recently been in London, and two of whom had certainly when there used the milk of the particular dairy. I failed to get evidence of the third case having partaken of that milk.

At Ascot the next cases after these did not occur until October 7. They occurred in the family of Mr. M. in children who had not been recently in London, but had been since June residing at Mr. M.'s house, "The Hermitage," situated in the plot of land immediately adjoining the Ascot Wood grounds to the eastward. The house itself was to the north-east of Ascot Wood House and on the same side of the road, and was

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at a little lower level than Ascot Wood House. Three children out of four (the youngest, an infant, not attacked) suffered from unquestionable enteric fever as follows: as soon as the first child attacked was convalescent, *i.e.* at the end of November or December, all the children were removed to Mayfair; the second of them attacked had epistaxis before removal, and the third was attacked within a few days of being brought back to town.

The following list shows the dates of attack (so far as they can be determined) of the succeeding cases, and it includes all the known cases of unquestionable enteric fever which occurred at Ascot, Sunninghill and Cheapside, during the period of time to which this report relates. I have marked thus * the instances in which cases occurred in families previously invaded, but not closely consecutive cases in the same family: and I have marked thus † the occurrence of the fever in houses previously invaded when occupied by a different family.

In looking down the column of dates it will be observed that there were frequently gaps of two or three months between consecutive cases, in which intervals no known cases of fever occurred; and between the last case in 1875 and the first case in 1876 there was a remarkable interval of 10 months, during which no case of fever is known to have occurred.

In the following list I have designated by Roman numerals the station of life of the family in which the case occurred thus: I., noblemen and gentry: II., middle class and tradesmen: III., labouring class and poor.

For convenience I have added to this table a column to show the milk supplies of the several families, thus anticipating a matter which will come under discussion later in the Report. In this column the letters B.K.F. signify Brick-kiln Farm, M. the particular Marylebone milk supply above referred to, and C. Chew.

The initials in column 3 do not in all cases indicate family relationship.

Consecutive cases.	Date of attack on 1st medical attendance.	Name.	Sex.	Age.	Residences.	Stations in life of families invaded.	Milk supply within ordinary incubation period.
	1873.						
1	July 25	E. P.	M.	10 yrs.	"Heatherfield," Ascot	I.	M. & B. K. F.
2	Aug. 3	— C.	M.	9 „	"Ascot Wood House"	I.	M. & C.
3	„ 10	S. M.	F.	—	"Firbank," Ascot	I.	B. K. F.
4	Oct. 7	F. M.	F.	3 „	"The Hermitage," Ascot.	I.	B. K. F.
5	End of Nov. and beginning of Dec.	M. M.	F.	4 „	„ „	I.	
6		B. M.	F.	5 „	„ „	I.	
7	Dec. 3	*Miss T.	F.	25 „	"Firbank"	I.	B. K. F.
	1874.						
8	Jan. 13	Rev. — C.	M.	—	Cheapside	I.	B. K. F. (?)
9		A. C.	F.	—	„	III.	Col. Hayes' farm.
10	Feb. or Mar.	G. K.	F.	11 „	„	III.	Savory.
11	—	M. K.	M.	13 „	„	III.	Savory.
12	Mar. 25	Mrs. W. C.	F.	—	Keep's Corner	III.	B. K. F.
13	June 16	†Lord E.'s son	M.	5 „	"Ascot Wood House"	I.	B. K. F.
14	Sept. 10	L. O.	M.	2 „	"Westwick Lodge," Ascot.	I.	B. K. F.
15	„ 20	T. O.	F.	8 „	„ „	I.	
16	Oct. 8	D. O.	F.	6 „	„ „	I.	
17	„ 10	Hon. Mrs. C.	F.	—	"Whitmore Lodge," Sunninghill.	I.	B. K. F.
18	Nov. 9	Mrs. C.'s housemaid.	F.	—	„ „	I.	
	1875.						
19	Mar. 6	Lord G.'s child	F.	3 „	"Inglemere," Ascot	I.	B. K. F.
20	Mar.	Miss M.	F.	28 „	Titness Cottage, Sunninghill.	I.	B. K. F.
21	June 29	†E. W. (cook)	F.	26 „	"Westwick Lodge"	I.	Master's own cows.
22	Aug. 12	†M. S.	F.	27 „	"Ascot Wood House"	I.	B. K. F.
23		†A. S.	F.	7 „	„ „	I.	
24	Aug. & Sept.	†A. S.	F.	5 „	„ „	I.	
25		†H. S.	F.	3 „	„ „	I.	
26	Aug. 25	†Miss W.	F.	—	"Whitmore Lodge"	I.	B. K. F.
27	A few days later.	†Mrs. W.'s cook	F.	—	„ „	I.	
28	Aug.	— P. (coachman)	M.	—	Stables, "The Hermitage."	III.	B. K. F.
29	Sept. 18	Mrs. A'C.'s child	F.	7 „	"Ascot Wood Cottage"	I.	B. K. F.

Consecutive cases.	Date of attack on 1st medical attendance.	Name.	Sex.	Age.	Residence.	Stations in life of families invaded.	Milk supply within ordinary incubation period.
	1876.						
30	July 11	Mrs. B.'s son	M.	17 yrs.	Sunninghill	II.	B. K. F.
31	Do.	„ daughter	F.	—	„	II.	B. K. F.
32	Aug. 3	M. V.	F.	9 „	Racecourse Lane, Ascot	III.	B. K. F.
33	„ 5	J. C.	M.	16 „	Brick-kiln Farm	III.	B. K. F.
34	„	J. S.	M.	—	New Mile Lane	II.	B. K. F.
35	„ 15	E. B. (nurse)	F.	39 „	Heath Cottage, Ascot	I.	B. K. F.
36	„ 21	E. P.	M.	15 „	Cheapside	III.	B. K. F.
37	Sept. 5	E. B.	M.	13 „	Main Road, Ascot	II.	B. K. F.
38	„ 25	C. L.	M.	23 „	"Glen Ogle," Sunninghill.	I.	B. K. F.
39	„	Col. L.'s maid servant.	F.	—	„ „	I.	B. K. F.
40	Sept. 11	Mr. S.	M.	—	Sunninghill	II.	Lovejoy.
41	„ 25	Mrs. S.	F.	—	„	II.	Lovejoy.
42	Oct. 1	*A. S. (nurse)	F.	Abt. 16	Heath Cottage, Ascot	I.	B. K. F.
43	„ 4	*Mrs. M.	F.	—	Titness Cottage	I.	B. K. F.
44	„ 28	— C.	F.	—	Cheapside	III.	Imported from Frimley.
45	Nov.	Mrs. D.	F.	—	Racecourse Lane	III.	B. K. F.
46	„	2 children	—	6 yrs.	„ „	III.	B. K. F.
47	„	2 children	—	3 „	„ „	III.	B. K. F.
48	„ 2	— M. (footman)	M.	23 „	Lord J. P's, house, Sunninghill.	I.	Lovejoy.
49–52	„ 3	Mrs. H.'s 4 children.	—	4 years and under	"Kingswick House," Sunninghill.	I. I. I. I.	B. K. F.
	1877.						
53	Jan. (end of)	— A.	M.	4 yrs.	Racecourse Lane	III.	B. K. F.
54	Feb.	— A.	F.	2 „	„ „	III.	B. K. F.
55	April 22	Mrs. W. P.	F.	62 „	New Mile Lane	II.	B. K. F.
56	May 13	J. E.	M.	7 „	Sunninghill	II.	B. K. F.
57	„ 20 & 23	Sir H. H.'s children.	F.	9 „	"The Wilderness," Ascot.	I.	B. K. F.
58			M.	—			
59			M.	—			
60	June 14	S. E. D.	F.	4 „	Racecourse Lane	III.	B. K. F.
61	„ 22	W. D.	M.	14 „	„ „	III.	B. K. F.
62	„ 30	E. A. (servant)	F.	14 „	New Mile Lane	II.	B. K. F.
63	July 23	A. T. (do.)	M.	14 „	„ „	II.	B. K. F.
64	Aug. 5	Mrs. B.	F.	— „	Sunninghill	II.	B. K. F.
65	„ 18	*A. C. (servant)	F.	18 „	New Mile Lane	II.	B. K. F.
66	„ 24	— G.	M.	12 „	"Frognall," Sunninghill.	I.	Own cows.
67	„ 29	*Mrs. H.	F.	— „	New Mile Lane	II.	B. K. F.
68	Oct 12	*F. M. E.	M.	3 „	Sunninghill	II.	B. K. F.
69	Nov. 4	*Mrs. P.	F.	52 „	Cheapside	III.	B. K. F.

There were thus altogether 69 cases of which 36 were children or young people under 16 years of age. The number of separate families invaded was 40, among which there were 21, or more than half, in which more than one case occurred (*i.e.* two to four cases). It is to be observed in respect of this multiplication of cases in a family, that, in most of these 21 instances, the cases happened concurrently or in near sequence, but that in four instances (Nos. 7, 43, 68, and 69) a period of time varying from 4 to 19 months elapsed between the cases. The number of separate houses invaded was 36, and of these seven were invaded more than once at intervals of 4 to 19 months. Of the seven houses reinvaded, one (Ascot Wood House) was invaded three times at intervals of 10 and 14 months, when in occupation of three distinct families; one (Westwick Lodge) twice, at an interval of eight months, when in occupation of two distinct families; and one (Whitmore Lodge) twice at an interval of 10 months while in occupation of two distinct families.

I have included among the 69 cases of fever seven which were not actually attacked with the disease within the infected district, but whose first obvious illness commenced a few days after leaving it to return home to London or elsewhere, viz. Nos. 5, 6, 13, 16, 19, 25, and 35. These were attacked at periods of 1 to 10 days after leaving Ascot. Some were evidently sickening before they left. Of the seven cases, five were from families in which other cases occurred, which cases passed through the disease or part of it at Ascot or within the infected area.

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In looking for the cause or causes of this epidemic, let us consider--

I. *What is to be gathered from coincidences?*

In an inquiry into an epidemic such as this, where the cases of the disease are distributed about a district having certain common features, there are four sources which are ordinarily looked to as those whence the contagium of the disease is most likely to have proceeded and by the medium of which it may have been distributed, viz.: 1. A common source of water supply, such as some particular well or stream, or the mains of a system of public supply, in which case infection of the water, either at its source or in its progress for distribution, may result in the distribution with it of an infective material. 2. A common system of drainage, in which case a sewer becoming infected may be the means of distributing, through the medium of the sewer air, infective matter to the houses in relation with such sewer. 3. Where there is no common water supply and no common system of drainage to account for a wide distribution of fever, the cause of the spread may be found in the progressive infection of independent privies, &c., and by soakage from them into independent wells or other supplies of drinking water; or (4) the cause of the spread may be found in the distribution over the district of some particular article of food, such as milk, which has become infected.

With a view to the full understanding of the present very difficult case, it will be well to consider these ordinary sources of infection severally, and I shall do so in the order in which they have been mentioned.

1. There is no common water supply, in the sense in which I have used the term, to the district or to the houses that were invaded. The drinking water of the district and of almost all the houses invaded is derived from wells close to the houses, and most of them are sunk into and gather their water from the "running sand" before mentioned as underlying the firm sand on which the houses are built; and it will be one of the contentions of my argument (subsequent indeed, and incidental to the main contention) that the water in this layer having become infected might have been the medium of infecting one particular well. Similarly it might be argued, other wells drawing upon the same water layer might have become infected, and in this way the disease have been spread through the district. I am not prepared to deny that in some instances this may have happened; but that it was not the main cause of the spread of the fever, and could have had at the most but a very small influence over it, is proved by the fact to be presently pointed out, that, even assuming all the houses invaded to have drawn well-water from this layer (which was not the case), very few indeed of the whole number were attacked; while among those that were invaded there was something else in common and differentiating those houses from others that took water from the same source. To attribute the spread of the fever to this cause would, under the peculiar circumstances of the case, be almost as unreasonable as to attribute it to the general atmosphere which the population breathed in common.
2. There is no common system of drainage in the district, so that this source of infection must at once be eliminated from consideration.
3. The third ordinary mode of spread of infection is not so easily disposed of. Throughout the infected area there are sanitary defects of the kind too commonly found in rural districts, which defects not only might have had a part in spreading the fever, but most probably were to some degree operative in this way; these various sanitary defects have reference mainly to the mode of disposal of excrement and slops, and the relation of the mode of disposal of these matters to the water supply for drinking purposes. The larger residences in the district, and all or most of the middle-class houses, have waterclosets which discharge into brick cesspools, sometimes cemented, but in other instances not cemented within. In the former case the contents of the cesspools are from time to time pumped out to manure and irrigate gardens, or the overflow is carried, as at Ascot Wood House, to a distance from the house, and at the point of exit allowed to soak into the ground. In the latter case a direct soakage into the ground is constantly going on. The cottages of the poorer classes and most of the houses of shopkeepers and persons of that class, are provided with ordinary cesspit privies, usually so constructed as to permit of soakage of the contents of the cesspits into the ground. House slops are either at once thrown upon the ground, or, being carried away by drains to a distance, ultimately soak into

the ground in like manner. In two instances the drains leading from the waterclosets of good residences to the cesspool were, when it was necessary to examine them after an invasion of fever, found to have been so badly constructed originally as to be leaky, and to require reconstruction; and what was discovered in these instances is not unlikely to be existent in other instances where no such examination has taken place. The drinking water is that drawn from wells, sometimes (even in the best residences) sunk within the basements of the houses themselves, in no instance more than a few yards from the houses, and in many instances dangerously close to the cesspits and house drains. Having regard to the fact that the ground intervening between the cesspits and drains and the wells is in all cases a highly permeable sand, which becomes wetter and wetter as the depth increases, until its high saturation with water destroys cohesion of the sandy particles, the very great liability of the wells to become polluted by any soakage of foul matters into the ground, must at once be obvious. In some instances which have come to my knowledge during the inquiry, the foulness of the water in wells, as much as 36 feet deep, from this cause has been such that the use of the water for drinking purposes has been spontaneously abandoned. I have discovered only two undoubted instances in which water, other than well water, is used in the district. I refer here to the use for drinking purposes of water from a brook issuing from the great pond at Sunninghill Park, passing Mr. Eel's farm at Smith's Green, and across the roadway at the bottom of the hill at Cheapside, which brook receives, among other things, the drainage from some privies, &c. at Cheapside. There is also by the roadside at Cheapside a little tank or reservoir of water, dignified by the name of a well, which is open to occasional pollution by the sewage of some neighbouring cottages, but which water is nevertheless used for drinking purposes.

I shall have occasion, as the Report proceeds, to point to some instances in which the fever may be believed to have been spread through the medium of infected privies, and of wells infected by soakage from them through the ground, or of a stream receiving the drainage of infected privies. But against this explanation as the main fact upon which the epidemic's spread depended, there are these considerations, viz. :—

a. That the condition of things described as respects privies and drinking water had been in existence for many years prior to 1873 ; and although by importation or otherwise cases of fever had now and then occurred in the district, the disease had notwithstanding never before, in the experience of the oldest medical practitioner there, spread epidemically.

b. That in many instances the houses invaded (following the chronological order of their invasion) were situated at a long distance from one another, in some instances more than a mile ; and that in very few instances indeed, even in the case of invaded houses situated near each other, have I been able to discover any communication of any kind between their inmates, and especially of such a kind as would lead to any probability of persons attacked with the disease having infected the privies of any houses subsequently invaded.

c. That on the other hand in the few instances where communication between the occupants of houses one of which had been invaded was of ordinary occurrence, or of more or less probable occurrence, and where therefore it was possible that the privies of one house might have been infected by having been used by an occupant of another house, fever did not spread from one house to the other.

d. Lastly, apart from any question of infection of privies or water from some previous case, it is not a fact that the houses in the district, the arrangements of which in respect of the disposal of excrement or sewage or in respect of water pollution were faulty, were those solely or even principally invaded. With the exception of a few houses at Cheapside, the first 27 cases occurred in houses the sanitary arrangements of which, although not always unexceptionable, were far superior to those of houses occupied by a large part of the population who yet escaped fever.

4. With respect to the fourth ordinary cause of the epidemic spread of fever, a fact which attracted attention, and which will have to be accounted for (if possible) in reference to each of the two apparently distinct epidemic outbursts, namely, that apparently ending in September 1875 and that apparently commencing in July 1876, is that the families invaded at each outburst were almost exclusively those supplied with milk from the suspected dairy, known as Brick-kiln Farm. It

becomes my duty, under the present heading, first, to inquire whether an influence of this kind was operative; and if found to have been operative, secondly, to what extent other circumstances, such as have been last considered, operated in conjunction with it.

There are three farms from which during the period of the fever prevalence milk was principally sold to the various families within the area, viz. Brick-kiln Farm, Chew's (subsequently Lovejoy's) Farm, and Belworthy's. Of these Brick-kiln Farm is the largest by far, and supplied the largest number of families. Each of these three dairymen has given me a list of the families he has supplied during the period of fever prevalence, these families being some of them the families of visitors as well as of permanent residents. I have confirmed the accuracy of these lists by inquiry in a large number of instances. The number supplied by each of these dairymen is as follows:

Critcher (Brick-kiln Farm)	100 families	
Chew, subsequently Lovejoy	46 ,,	
Belworthy - - -	16 ,,	and in addition occasional customers.

In addition to these sources of milk supply, I have a list of families (drawn up by Dr. Woodforde) which have during the period of fever prevalence been regularly supplied by cows kept by themselves. There are on my list 27 such families. Some of them gave away milk to their friends and dependents, so that the number of families thus supplied was larger than this number indicates.

The 40 families mentioned at p. 4 as having been invaded, include one (No. 44) into which the case of fever was imported from a distance, and could not have had its origin in any Ascot milk supply. Deducting this case, therefore, we have to consider the milk supply of 39 families and 68 cases. These families and cases had been supplied with milk from Ascot sources at the time of invasion, and with one exception (No. 2) for some weeks at least previously, as follows:—

By Critcher - - -	58 cases in	31 families,	or 31	per cent. of the families taking that milk.
,, Chew or Lovejoy -	4 ,,	3 ,,	6·5	,, ,, ,,
,, Belworthy - -	0 ,,	0 ,,	0	,, ,, ,,
From their own cows -	2 ,,	2		
From other private sources	3 ,,	2		
	67*	38		

Primâ facie, then, there appears a strong probability that the prevalence of enteric fever has been in some way, and to some degree, associated with the milk supply from Critcher's farm. And this *primâ facie* evidence turns out to be strengthened by more particular inquiry. For on deducting from each series of cases (viz., the series using the Brick-kiln Farm milk, and the series using milk from other local sources,) those cases which certainly contracted their disease elsewhere or had an opportunity of contracting it elsewhere by having been away from the neighbourhood at some time during the ordinary incubation period of enteric fever, the account between the two series of cases stands thus, viz.:—

1. Cases using Brick-kiln Farm milk - - - - -		58
Contracted their fever in London (Nos. 1 and 3) - -	2	
Away from the neighbourhood during some time of the ordinary incubation period (Nos. 30, 31,† and 38.) - - -	3	
Deduct	5	- 5
Certainly became infected in the district		- 53

* Case No. 8 was also supplied by Critcher at the time of the commencement of the illness, and had been supplied by him for some days previously, but for what exact length of time I was unable to ascertain. Hence I have omitted enumerating it among the cases so supplied.

† Probably Nos. 30 and 31 also contracted their fever in the district. They accompanied a school excursion to Brighton only five days before they were first seen by their medical attendant; and no other case of fever is known to have occurred among either the grown-up persons or the children who joined the excursion.

2. Cases using milk from other local sources - - - -		9
Contracted the fever in London (No. 2), at Rochester (No. 66),	2	
Away from the neighbourhood within ordinary incubation period, and exposed to sewer emanations in a mews-dwelling in London - - - - - - - -	1	
	3	3
Became infected in the district -		6

These numbers show a proportion between the cases infected in the district and using the Brick-kiln Farm milk to those also infected in the district and not using it, of 8·88 to 1.

I shall have occasion to point out, as the Report progresses, that in respect of particular cases within both series (the series of 53 and the series of 6,) there were conditions or circumstances existent which may suffice to explain the occurence of the fever independently of the circumstance of a particular supply of milk having been drunk. But the difference here in the two series is this, namely, that whereas only a small and uncertain proportion of the Brick-kiln Farm series can possibly be thus explained, all the six cases of the series not supplied from Brick-kiln Farm, viz. Nos. 9, 10, 11, 21, 40, and 41, are explicable in this way. I shall refer again (p. 10) to the probable origin of the cases Nos. 9, 10, 11, 21, and need only here state that No. 40 had within a fortnight of his attack been occupied in making alterations in a watercloset of a house at Sunningdale, where he had been exposed to offensive cesspool emanations, that his wife, No. 41, was attacked about a fortnight later, and that both of them had also been exposed for some time previously to the offensive effluvia from a privy which had overflowed at the rear of their house.

The nine cases, which certainly did not use Brick-kiln Farm milk, being all thus capable of having their origin explained in various ways independently of any question of milk consumption, we have to deal with the remarkable fact that the remaining 53 cases, which certainly became infected within the district, all used the milk from Brick-kiln Farm.

Looking now to particular cases as illustrating what so far appears accusatory of the Brick-kiln Farm milk supply, the following facts are noteworthy:—

a. Ascot Wood House, the residence of Sir J. L. has, since 1866 been let to various families during the summer season; and up to 1873, when Mr. C.'s son (No. 2), who acquired his disease in London, was ill there in August, it is said, and I believe with truth, that there had been no case of fever in the house, either in those families or their domestics. On the C.'s leaving, the house was occupied during the winter by Sir J. L. In the early part of 1874 Lady G. with her family and domestics occupied the house for two months. No fever occurred in either family. Up this to time I am informed that the milk supply of the house, both to Sir J. L.'s family and to the visitors, was from a dairyman named Chew, whose business was subsequently taken up by Lovejoy. In April 1874, Lord E.'s family came to reside there, and for the first time the house was supplied with milk from Brick-kiln Farm. In June Lord E.'s son (No. 13) was attacked with the fever. In August and during the winter the house was occupied by Sir J. L. and his family, and the supply of milk from Critcher was continued. During the winter several members of the family and domestics were ill. The illness consisted of pulmonary affections, with, in one instance, aphthous mouth, and febrile attacks with sore throat and abscess. A manservant, aged 35, certainly had in the month of December (first seen December 21, last seen January 11,) an attack of some severe febrile disease. Mr. Brown, who attended him, tells me that he cannot now recollect the exact nature of his illness; so that although it is not improbable that it was enteric fever, I have not felt justified in including it in my list of such cases. Some of these attacks of illness were attributed at the time by Mr. Brown to the severity of the weather. In the month of February the milk supply was changed, and no case of fever or other illness occurred either in Sir J. L.'s family or in the family which occupied the house during part of June. In July however the house was occupied by another family, who obtained their milk supply from Brick-kiln Farm, and in this family four cases of fever (Nos. 22, 23, 24, 25), occurred during the months of August and September. On their

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leaving, the milk supply was again changed, and the milk was obtained from a private source. Since that time no case of fever has occurred either in Sir J. L.'s family or in other families that have occupied the house. The only occasions on which fever has happened there have been when the milk supply was derived from Brick-kiln Farm.

b. Ascot Wood Cottage is situated about 130 yards to the west of Ascot Wood House. With the exception of the race week, when it is annually let to visitors, it has mostly been in the occupation of the owner, Mr. G. L. From January 1873 to February 1875 (with the exception of two months in July 1874, when Ascot Wood House was occupied by them) it was in the occupation of Lady G. and her family, and in August and September 1875 in the occupation of Mr. A'C. and family. These two last-named families obtained their milk supply from Brick-kiln Farm (both being on the list given me by the dairyman), but the family of the owner of the house does not appear to have been so supplied (his name not being on the list). No fever occurred in the house until August, 1875,* when the family then in occupation was invaded by fever (No. 29). They had left the milkman who then supplied the house, and obtained their milk from Brick-kiln Farm.

c. New Mile Lane contains 12 houses occupied by separate families, of which six are and for a long time have been supplied with milk from Brick-kiln Farm, while six are and have been supplied from other sources. Of the six families supplied by the farm four have had cases of fever (two of these each two cases), in them, while of the other six none have been invaded by fever.

d. A family at Sunninghill has for several years used none other than condensed milk. One of the family, a boy aged seven years, being a favourite of his grandfather, resided with him in a neighbouring cottage. His grandfather's family used the milk from Brick-kiln Farm, and in May 1877 the boy was attacked with enteric fever. On his recovery a younger brother, aged three years, also went to live with the grandfather, and in October he also was attacked with the fever, the family at home not having been invaded.

e. On January 18th, 1875, five children of Lord G.'s went with three nurses to "Inglemere." The owner of the house kept cows for the supply of his family, and the children had the milk which they furnished up to February 22. On February 23 (this supply failing) milk began to be taken from Brick-kiln Farm, and from the 28th onwards to April 10, all the milk for the household was derived from thence. The children returned to London on March 16, and on the 17th one of them (who had been ailing for more than a week,) was attacked with enteric fever. The children had not visited anywhere during their stay at Ascot, and had taken most of their exercise in the grounds attached to the house. Dr. Buchanan, who at that time made a careful examination of the premises, failed to discover any local cause. There had been no fever in the house previously, and there has been none since.

f. On April 10, 1877, Sir H. H. and family, with their three children, took possession of the Wilderness, Ascot, an old house not free from sanitary defects, but in which no case of fever is known to have previously occurred. The family generally were supplied with milk by Lovejoy; but in order that the children might have milk always from one and the same cow, the children's milk was specially provided by Mr. Morton, who kept but one cow. This cow ran dry, however, and then Mr. Morton said he would get milk for the children from another source. This source turned out to be Brick-kiln Farm, and from May 7 to May 28 the children drank milk supplied from this source alone. At that time Mr. Morton's own family and another family that he supplied obtained their milk from Lovejoy. There was no illness in any of these families except in that of Sir H. H., one of whose children was attacked with enteric fever on May 20, and the other two were attacked on the 22nd. From May 28 onwards all the milk for the family was supplied by Lovejoy, and no further illness occurred.

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* This statement requires qualification. In April 1873 one of Lady G.'s children aged three years had an attack of "fever," and another aged five years had an attack in August 1873. Both children had had "fever," believed to be of malarious origin, in Mauritius, and these new attacks were believed to be recurrences of the same fever. They were not at the time regarded as cases of enteric fever, and I am informed that Sir W. Jenner, who saw one of the cases, thought it probable that it was a case of recurrence of the Mauritius fever; I have therefore abstained from putting them in my list.

g. On November 1st, 1874, Mrs. G. (who had had enteric fever some years previously), with two children aged 2½ years and 16 months, and two nurses, took lodgings at Gothic Cottage: she and the children had Critcher's milk, but the nurses boarded with the lodging-house keeper, and had Lovejoy's milk. On December 20th both children had diarrhœa, and the younger one severely, with fever, swollen face, sore mouth, and abscess on the thumb. Dr. Liveing, who saw the child, suspected but did not actually diagnose enteric fever (hence the case is not entered on my list). The nurses escaped. In 1875 Mrs. G. again visited the neighbourhood, this time taking a furnished house at Sunninghill, with the same children and nurses. There she had Lovejoy's milk, and no illness occurred. In June 1876 the same party came to Ascot a third time, and occupied Heath Cottage on the Wingfield Road, and near the north-west corner of the racecourse. There they were a second time supplied from Brick kiln Farm, the whole of the family using it. On this occasion both the nurses suffered from enteric fever. The elder one, aged 39 years, left Mrs. G.'s service on August 5th, and was then complaining of headache and illness; she took to her bed on August 15, and died on September 26. The younger woman, aged about 16 years, left Mrs. G.'s service on September 26, went home to her mother's house at Cheapside, and was first seen by her medical attendant on October 1st.

The facts which I have detailed can leave, I think, no doubt upon the mind that the use of milk distributed from Brick-kiln Farm was in some way directly associated, as cause with effect, with the distribution of 'enteric fever through the Ascot and Sunninghill districts during the long period of 4½ years.* It is no valid objection to this inference to say that many families to which this milk was distributed have hitherto escaped invasion, and that a few families which used milk from other sources suffered similarly from fever. The obvious reply to the first of these objections is, that in no milk epidemic hitherto investigated has more than a fraction (although usually a large fraction) of the families using the infected milk been invaded; and to the second objection, that the operation of one predominating cause of an epidemic of fever by no means precludes the operation of other causes concurrently existent. I have already suggested that there were other causes of fever operating within the district, and I now proceed to consider these causes, and the effect they may have had in extending the operation of the predominating cause. It is the more necessary to do this, inasmuch as it has been suggested that they have alone sufficed to account for the entire epidemic.

It is highly probable that the various sanitary defects observed in the infected area were more or less operative in spreading the epidemic. Thus they probably had to do with cases Nos. 9, 10, and 11, which immediately followed the case of the Rev. Mr. C. at Cheapside (where the drainage arrangements and water supply are especially objectionable) in 1874, which cases occurred in persons not supplied with milk from Brick-kiln Farm. With high probability also defects of this kind had to do with the fever at Westwick Lodge, which on two occasions affected consumers of the Brick-kiln Farm milk (Nos. 14, 15, and 16), and on a subsequent occasion attacked the cook (No. 21) who took none of that milk. On examination, subsequently to the last attack, of the drains leading from the closet to the cesspool, it was found that they had been constructed of ordinary earthen non-socketed drain pipes which passed close to the well; the soakage from this drain had passed through into the ground, and could be seen to have oozed through the brickwork of the well. It is probable that the filth had passed into the water, not only laterally in this way, but also, by direct soakage, downwards into the water layer. It is not unlikely that other cases, in families supplied with milk from Brick-kiln Farm, may have had their origin in a similar manner, and that thus not only may some of the multiple cases and repetition of invasions in the same or different families in individual houses (marked with * or † in the list) be explained, but perhaps some invasions of families where only single cases have occurred; as, for instance, the prevalence of the disease in Racecourse Lane and New Mile Lane, the former in the later months of 1876 and the earlier months of 1877, and the latter (with only one exception) in the period between April and August 1877. Again, it is not at all improbable that the second case (No. 69) at Mrs. P.'s cottage at Cheapside in November 1877, was due not to the use of the milk

* The low fatality which has attended the epidemic corresponds also with experience as to other epidemics of enteric fever due to milk, only 2 persons out of the 69 enumerated in the table at page 3 died, viz. Nos. 35 and 69.

from Brick-kiln Farm, although this was used, but to the use for drinking purposes of the water of the neighbouring brook, into which in seasons of rain sewage from the privy used by A. S. (No. 42) who was ill with the fever in October 1876 was inevitably washed, and which was also liable to pollution from the privy of the cottage itself, in which a case of fever (No. 36) had occurred in August 1876.

I am bound in discussing the causes of the epidemic to take all these circumstances into consideration, and to show how they may be regarded as limiting and reducing the direct influence of the milk supply in its causation. But, while making every possible allowance for the operation of these circumstances, there still stands prominently out from all of them the one fact, that nine tenths of the persons attacked were persons who used the milk from Brick-kiln Farm.

This, then, is the evidence on which the epidemic is regarded as having been related to milk supply. It points to the Brick-kiln Farm supply as having been concerned with the great majority of the cases of fever. The questions now to be discussed are quite independent of the question the discussion of which is now finished.

II. *The circumstances of Brick-kiln Farm and Dairy as affording opportunities for contamination of the milk with "filth."*

It is necessary first to describe Brick-kiln Farm, and the arrangements under which the business there was conducted.

The farm is situated rather less than half a mile to the north of the main road at Ascot, and about 300 yards to the east of the road leading from that place to Wingfield. It is not visible from the Wingfield road, in consequence of its situation in a hollow or excavation made at a time when clay was dug here for the purpose of brickmaking. It is isolated. The nearest house to it is an isolated cottage, a farmstead about 250 yards off to the northwards, beyond which, at a distance of another 250 yards, is a small group of cottages, known as Keep's Corner, in one of which cottages resided in 1874, a son of the dairyman with his wife and family of several children. There is no drainage arrangement common to these three several premises.

The family of the dairyman consisted of himself and his wife, both advanced in life, and a daughter, a young woman. In addition he had in his employ and sleeping in the house a boy, aged 16, from Michaelmas 1875 until he left from illness in the autumn of 1876. The work of the farm has been done by himself and a labourer or carter. From the beginning of 1874 up to August 1875 he was assisted by his son, who lived at Keep's Corner; subsequently he had a stranger, not residing at the house, to assist him. The son, or a grandson, milked the cows; the dairyman's wife and daughter managed the dairy, and the milk was mostly carried out by himself, his wife and daughter, but sometimes by his son or by the boy who lived at the house. He says that no labourer, not of his family, ever carried out milk. He further asserts that he received no lodgers, even during the race week. The labourers and persons not living in his house used the privy in the further yard.

Plate 1. is a general plan of the premises. The dwelling-house is an old house facing the south-west, having in the front a garden and pond, and at the rear a farmyard with farm buildings on two sides and part of the third. Beyond the farmyard and entered from it through a gate is another yard or small field. In this yard was a very filthy cesspit privy said to be used by the farm work-people only. The principal farm yard was not paved, but the middle of it was depressed and occupied over a large space by an accumulation of cow manure, and water that had drained from the surface of the yard and the roofs of the buildings. The dotted line in the plan indicates the position of this accumulation of dung and water. There were no provisions for its drainage. In the garden of the house and about 15 feet from it was a cesspit privy, having an overflow pipe formerly leading to an elongated hole in the earth or pit, (probably originally a hedge-side ditch,) which used to be open, but was at the time of my visits covered up and invisible. From this hole such liquid matters as did not soak in used to be conveyed away by a pipe drain to a small brick receiver (14 × 9 in. superficial measurement and 3 feet deep,) from which another pipe drain led to an open field ditch. In December 1875 this old ditch was filled in and a pipe was laid throughout the length of it, as shown in the plan. The cowsheds, very imperfectly paved and dirty, were drained into a cesspool, having an overflow pipe into the same field ditch; but at the time of my visit this pipe was ineffectual for the relief of the cesspool, and hence the custom was to empty the latter from time to time upon

the dungheap in the centre of the farmyard. The drainage arrangements of the house itself were as follows.

Plate 2. is a ground plan of the dwelling-house. Under the window in the kitchen there was a stone sink, with a broken brass strainer at the entrance to a pipe which passed below through the wall of the house into an underground brick drain: this drain passed across the house yard, and in the farmyard terminated in an underground drain made of loose tiles, the bottom tiles being flat and the upper tiles arched, which drain ran across the yard to the same receiver in the field in which the privy drain terminated. This sink drain was nowhere trapped. When the drains were opened for examination on July 10, I found that just mentioned as crossing the farmyard very imperfectly laid, leaky, and nearly choked up with filthy black deposit. There was about 1 foot depth of similar black deposit in the receiver in the field, which was at that time covered over with a block of wood. Thus there was a free passage for any drain air generated within the drains up the sink pipe into the sink and kitchen.

The water supply of the premises was derived from a well, the situation of which is shown upon the plans Plates 1 and 2. It was covered with a brick dome having an opening with stone cover in the middle. The well was steyned dry half-brick. It was 3 feet in diameter, and there was no obvious staining of the interior of the brick lining. Its total depth was 22 feet 6 inches, and at the time of examination, on July 10th, there was in it a depth of 6 feet of water. No filth came up upon the plumb weight. The pump was situated outside the house in the situation shown in Plate 2. It was enclosed in a wooden case. In front of it, and coming up flush to the case, was a stone sink, supported upon a square hollow pedestal of brickwork, so arranged, however, as to leave a free space or hollow narrow chamber, closed in at the sides by the brickwork, and above by the sinkstone, between it and the pump case. This space is shown at F. in Plate 3. A short branch brick drain passed underground from the house sink drain into the close cavity of the pedestal, within which it was quite open and uncovered. There was a pipe leading from the strainer of the sinkstone downwards through the hollow towards this open part of the drain, above which it terminated by an open mouth. The leaden pipe leading from the well came above ground in the space between the pedestal and the pump case, through which it passed by an opening cut in the case to the pump within. This opening in the case was much larger than was necessary for the passage of the pipe, and allowed of a free communication between the pump case and the cavity before mentioned as existing between the case and the pedestal. On July 10th, while making the examination of the drains, part of the front of the brick pedestal fell down, and then I first became aware of the fact that the drain had a free opening within the pedestal. Passing my arm into the hollow and feeling all round, I then also became aware of the fact that there was a communication through which I could pass my finger under the sinkstone, and between it and the brickwork, leading from the cavity of the pedestal to the cavity between the pedestal and the pump case. I now had the sinkstone carefully raised, and I found that the passage of communication which I had felt, really was caused by an irregularity of the top of the brickwork forming the back wall of the pedestal, which had not been filled in with mortar, and which the flat stone sink converted into a flat elongated opening.

It thus became apparent that there was an air communication from the drain into the cavity of the brick pedestal, thence through the irregular opening just mentioned into the interval between the pedestal and the pump case, and further through the hole for the well pipe into the pump case, by means of which circuitous communication the air in the pump case would necessarily receive an admixture of any air generated within the drain, or entering it from any drains that communicated with it.

The iron cistern forming the top of the pump within the case was about 12 inches square, and proceeding from the leaden portion below it, there were at different levels three pipes or spouts. The uppermost spout was that leading towards the outside sink. The two lowermost proceeded the one to the kitchen sink, the other to the copper within the kitchen. These several spouts were not provided with taps, but in place of them, when water was required from either of the upper spouts, that or those below were stuffed with old rags. I had the curiosity to open out the rags stuffing up the spout over the kitchen sink. It consisted of white and coloured rags partly cotton, partly linen, and partly woollen, the coloured rags being apparently a part of a print dress. I was told they were the remains of an old kettle holder.

On this same day (July 10) I visited the farm early, in order to be in time to see how the milk cans brought home after the milk delivery were dealt with, and I remained long enough to see the cans sent out for the afternoon delivery. On a former occasion I had observed empty milk cans inverted over the sink and over the opening of the

drain pipe. It has already been pointed out that the sink hole was in direct communication with the drain, and consequently there was a certainty of milk cans thus placed being befouled by drain air. I had further noticed that the sink stone was dilapidated and had scaled off in places so as to form depressions in which dirty water lodged, and generally that the sink was kept in a filthy condition. On this occasion I noted the same facts, and observed the process of cleaning the cans. They could not be said to have been "scalded," since the water used for washing them was far from being "scalding" water, and I could very well bear my hand in it. A large pan was placed in the sink and partly filled with hot water from an adjoining scullery. In this pan the cans, large and small, were washed successively, and in washing them a rag, which when not in use I saw lying sometimes in the dirty sink, or a scrubbing-brush was used. The cans were then rinsed out with cold water from the pump, and were then inverted to drain either upon a wooden bench in the yard outside, or upon the sill of the window within the kitchen and close to the sink. Probably in wet weather more would be drained in the kitchen, somewhere about the sink, than outside the house. I saw the cows milked and the milk strained into the cans in which it was to be carried out. This latter operation was conducted within the kitchen. All the vessels appeared clean. I am sure that the milk was not diluted or otherwise tampered with on that occasion.

On this occasion also I took a sample of water from the pump and sent it to Dr. Dupré for analysis. The result of his analysis is given in an Appendix to this Report. It indicated that at one period of its history the water had been largely contaminated by sewage or surface drainage, and the account I have given of the surroundings of the well sufficiently indicates from what sources (privies, dungheap, &c.) the contamination might have been derived. Dr. Dupré, however, goes on to say that, although "organic " matters thus added had been very completely oxidized," "the oxidation may not " always be so complete, and that then the water would be entirely unfit for drinking." At the best, knowing what we do of the circumstances of the water, it must be called a dangerous water, since, however complete may apparently be the oxidation of dead organic matter mixed with it, the oxidation of these matters does not necessarily imply the destruction by oxidation of the potency of any matter of contagion that the water may contain as a part of its organic impurities.

The above account of the condition in which I found the farm and dairy premises, and of the slovenly arrangements under which the business was conducted, indicates more than one way in which the milk might have become befouled. It is obvious that the cans in which the milk was sent out were liable every day or any day to befoulment even during the process of cleansing. The water used for rinsing the cans was a dangerous water to use, for the reasons just assigned, being doubly liable to befoulment, namely, first from the soakage of foul matters into the well from privies and the manure heap, and secondly from the absorption of the foul emanations from the drains which communicated with the pump case. After rinsing they were again liable to befoulment from drain emanations rising through the sink pipe over which they were sometimes inverted to drain. And finally, the milk itself might at any time have become befouled by standing in the room into which the sink pipe opened. In addition to all which, the brush used in cleansing the cans, and the rags used for the same purpose, or for plugging the pump spouts, might, from their constant vicinity to the sink pipe, have become fouled by the drain emanations, and thus have become a medium by which these filthy emanations might have been conveyed to cans. With respect to the open cistern within the pump case, I may point out that its circumstances were similar in all essential points to those of the water cisterns in many London houses, where the waste pipe opening above into the space between the water and the cistern cover is continued without any break or intervening trap into the house drain, and is liable to carry up sewer air into that interval, whence it may be absorbed by the water. There is abundant evidence to show that enteric fever has, in London, been frequently caused by the use of cistern water stored under such conditions. I have specially mentioned the circumstances under which the water used may have introduced a filth pollution into the milk by merely rinsing the cans with it, because former experience of milk epidemics of fever have demonstrated that given an infected water, the small quantity of such water which may hang about a milk can after rinsing with it is amply sufficient to infect the milk subsequently put in. The infection of milk by an infected water by no means implies fraudulent dilution of the milk with that water, of which, moreover, there is no evidence in this instance. I have made inquiries among the dairy customers as to the apparent quality of the milk supplied from the farm, and in only two instances (in families connected with one another, and in which strong opinions were held as to

the dependence of the epidemic upon this particular milk supply) could I hear of any complaints of its quality. In one of these families it was stated that the milk would not keep, and had been seen to have a black sediment in it; and in the other, that although no sediment had been observed, the milk was thinner than that supplied from another dairy, used sometimes to curdle during the night, and once or twice curdled when boiled. This would be very poor evidence in proof of dilution with water. I have also heard rumours of milk having been purchased from other farms with a view to supplement an occasional deficiency; but this is absolutely denied by the dairyman, who, although an uneducated and not very wise man, is, so far as I have been able to test his veracity, truthful and honest; and I have failed, after inquiry, to discover any reason to doubt his truthfulness in this respect or in any other. It is very important that attention should be specially drawn to the fact that befoulment of the milk cans in any of the ways indicated would be a particularly dangerous kind of befoulment, inasmuch as the pollution of the water in the well was an excremental pollution by soakage from privies and the dung pit, while the drain air came from a drain which, although not itself a privy drain, was in communication with a privy drain. It is under such conditions as these that polluted water and drain air are admitted on all hands to be most likely to become agents in the spread of contagious matter of enteric fever.

To all this I may add that there is an accidental way in which filth may gain access to milk, which must never be overlooked, namely, from the hands of the milker.

There is a considerable class of persons, among whom are many highly distinguished medical men, who do not contend for the necessity of a pre-existing case to explain the local origin and spread of enteric fever. These persons will probably consider that in giving evidence of the opportunities for contamination of the milk with filth, and particularly with excremental filth, all necessary proof has been afforded of the sufficiency of the alleged main cause of the epidemic, and that the inquiry might here be brought to a close.

III. *Had the "filth" that had access to the milk any opportunity of receiving specific infection?*

This is a further question, some attempt to answer which will be expected by those who subscribe to the doctrine that (putting mere possibilities aside as not matters of scientific argument) enteric fever contagium as we now meet with it has an ancestry; and however long and widely and through whatever media it may have travelled about prior to finding a lodgment suitable for its development in a human system, that it or its ancestor at one time issued with excremental matter from some individual affected with the disease. It is a doctrine which I myself provisionally accept as most in accord with my own experience, and also, so far as I have been able to judge, with that of the most competent and, let me add, most patient observers. With such as dissent from it I can agree in admitting that there is very much in the natural history of contagium in general, and of enteric fever contagium in particular, wrapt in an obscurity yet unpenetrated; but I am hopeful enough to look forward to the time when the advance of scientific inquiry will render that clear which is now dark. But however this may be, the doctrine is one which furnishes a salutary rule of practice in an inquiry such as the present, inasmuch as it is calculated to foster a minuteness of investigation which has at any rate the chance of being fruitful. I proceed then to indicate some ways, some possible, others more or less probable, in which the specific contagium of fever may have gained access to the farm. Should the reader of this Report, after due consideration, reject them all, there yet remains the thought that no observer, however anxious he may be to trace the course of events, is omniscient, and that some accidental circumstance about which he can learn nothing by inquiry, may be the clue to the explanation which he seeks.

I will state the facts bearing upon the question and endeavour to estimate their value.

1. First of all I may remark that I failed to learn from the fullest inquiry I could make of the medical men practising at Ascot or Wingfield, or of the medical man who attended professionally the occupants of Brick-kiln Farm, that there were at the time of the outbreak of the epidemic in 1873, or that there had been at all recently any cases of enteric fever or anything resembling it either in those neighbourhoods or at the farm. The first appearance of the disease was the occurrence of the cases Nos. 1 and 2 on the list, cases by which the infection was imported from London.

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2. The first and only case that happened at the farm during the whole course of the epidemic was that of the boy J. C. (No. 33).* He was not taken ill until the epidemic was considerably advanced, namely, not until August 5, 1876. This boy was exposed to the same chances as the customers of the dairy of getting contagium from the milk used in the family. It is quite possible and indeed very probable that the contagium contained in the boy's evacuations thrown into the privy did at that time infect both the well water and the drain, and this may account in part for the subsequent somewhat increased prevalence of the disease among the farm customers. But it leaves unexplained the infection of the milk prior to his attack.
3. The first and only case that happened very near the farm was that of the daughter-in-law of the dairyman, Mrs. W. C. (No. 12), residing at Keep's Corner. She was ill with enteric fever in March and April 1874, and when first seen by her medical attendant on March 25 was very ill. Her convalescence commenced about April 18. She might have contracted her disease from the use of the milk from Brick-kiln Farm, where her husband was at work daily or in some other way; but being attacked the contagium might have reached the farm from the premises which she and her husband (who did not suffer from the disease) occupied. If she did not contract her disease from the farm it is very difficult to suggest how she did contract it; for she told me she was not in the habit of visiting anybody but occasionally her father who resided in Race Course Lane, where at that time there was no fever, notwithstanding its much greater proximity to the first cases of the outbreak. It is to be remarked, with reference to possible spread of the contagium from Keep's Corner to the farm, that, if this was one of the sources from which the contagium reached the farm, it must have been a long while travelling there; since the next case on the list, No. 13 (about which there is the possibility of doubt whether the contagium might not have been acquired at the house where the case occurred), did not happen until June 16, and the next case after that, No. 14, until September 10. One hypothesis which has been suggested in connexion with this case I may dispose of at once. During the time of Mrs. C's. illness she was nursed by a neighbour, but her husband slept with her all through her illness and attended to her at night. She had severe diarrhœa. When her husband got up in the morning, he went to the farm and milked the cows, and an opportunity thus arose for the contagium being introduced from his hands or otherwise into some of the milk. But had it been introduced in this way into the farm milk, fever would scarcely have failed to appear among some of the dairy customers during or shortly after the wife's illness, which was not the case. This hypothesis must at once be rejected.
4. The privies at the farm (*i.e.*, the privy used by the family, or more probably the more distant privy used by labourers or others coming to the farm), might have become accidentally infected by being used by some person suffering from the fever in the early stage that permits of the sufferer still going about his business, and the contagium from the privy might have accompanied the other organic pollutions which soaked through the ground into the water layer into which the well was sunk. There is no evidence of such an event having happened, but, in the nature of the case, there is no probability of such evidence being obtainable. Nevertheless it may have happened.
5. I have now to invite consideration of the peculiarities of the water layer of the district which embraces the farm, Keep's Corner, and the ridge of hill on which the village of Ascot, where the first cases of the outbreak occurred, stands, and upon which water layer all the wells of this part of the epidemic area probably draw with the exception of the superficial wells. I invite consideration of the fact that the level of the subsoil water follows the inclination of the surface of the land, and that any movement of that subsoil water, such as might occur after much rain, would be in the direction of that inclination.

On the Ascot ridge there are, as I have explained, two inclinations, one a steep inclination to the south towards Sunninghill bog, and another, a much more gradual inclination, towards the north and north-east (*i.e.* in the direction of the farm). The

* Some doubt as to the nature of this case has been raised by the fact that, after his removal in an open cart from the farm to his house at a distance during his illness, he had an unquestionable attack of intercurrent pneumonia; but on careful and very full inquiry I myself believe that his primary illness was enteric fever.

direction of the flow of water, then, might be in either direction, but I have the authority of Mr. Whitaker, of the Geological Survey, for saying that in similar cases the movement is more commonly in the direction of the more gradual inclination than of the more sudden inclination, and hence in this case would be more likely to occur towards the farm than away from it. As a matter of fact the level at which the subsoil water stands (in the wells of Ascot Wood House and cottage) is just about from 7 to 10 feet higher than the level at which it stands at the farm,—a fall in the level of only 7 to 10 feet in something less than half a mile. Now I have ascertained that the excreta of the first case (imported from London) which occurred at Ascot Wood House (No. 2) were buried in a hole in the sand in a field adjoining the property on the southern slope of the hill, but not on it, and at a level about 20 feet lower than that of the house itself, and therefore probably some feet nearer to the water layer, which layer the infective matter contained in the evacuation might then readily, with the help of rain, have reached through the intervening sand. The vessels used for carrying the excreta were subsequently washed with water at the yard of the house, and the rinsings thrown into a ditch at the summit of the hill close to the yard, from which again infective matter might have percolated into the water layer. Furthermore, there was a leakage of the watercloset drains which must have received at any rate the earliest of the infected excreta, and from this source also the water layer might have become infected.* The hypothesis I wish to suggest is that water drawn from the well at Brick-kiln Farm at the expiration of, say, six weeks, and perhaps at intervals for a long time, after these or similar events on the ridge might have been water to which infective matter had at the time of such events gained access in the way above described.†

The criticism which might be suggested is, that the flow of the subsoil water, both at Ascot Wood House and at the southern slope of the hill where the evacuations were buried (looking at the plan, Plate 4, Fig. 2), would probably be to the south and not towards the farm. But as a matter of fact, there was on the southern slope of the hill, below the level of the spot where the evacuations were buried, no such issue of water by springs as might under such circumstances have been expected. The only spring on the hill-side—and that giving little more than a mere dribble of water—was to the north of that spot, besides which there were sundry patches of spongy bog lower down with small springs in them. Dr. Woodforde has, since my inquiry, made a further careful examination, and has arrived at the belief that, notwithstanding these little springs, the main movement of the water, even on the southern side of hill, is towards the north-east. Looking at the plan, it would appear that the infective matter sinking through the sand, whether from the hole or from Ascot Wood House, would reach the water layer at about or a little above the level of the water in the well at the farm; and looking at the fact of the absence of springs on the adjoining part of the southern slope, it seems probable that if the mass of subsoil water moved at all it moved mainly in a northerly direction, at all events at the level referred to.

I must confess my inability to come to any decided conclusion as to which of the several modes of infection suggested was that which was operative in first introducing the contagium of enteric fever into the dairy. The remarkable fact that the epidemic commenced with cases imported from London, and that the earliest cases after them were in families supplied from the farm, would appear, at the first blush of the case, to indicate that, somehow and by some secret passage, the contagium had reached the farm from one or more of these imported cases. But, after all, the fact that cases Nos. 4, 5, 6 and 7 were supplied by milk from the farm might have been nothing more than a coincidence—although a very remarkable coincidence, looking at the future course of events. The fact of the milk supply of No. 3 is pretty certainly, and of No. 7 perhaps, to be thus regarded; that of No. 4 may be also a coincidence, and the cases Nos. 5 and 6 may perhaps be regarded as of local origin out of case 4. About the milk supply of case No. 8 nothing is known with absolute certainty, and cases 9, 10, and 11 probably originated in some way from case 8; they had certainly nothing

* It is said, and I believe correctly, that some disinfectant, it is believed Condy's fluid, was used to the excreta prior to the burial of them; but I am disposed to place little reliance upon any supposed disinfections, unless carried out to the extent that they are rarely if ever carried out except under the direct supervision of some one, medical man or nurse, thoroughly conversant with the art of disinfection, and thoroughly alive to the difficulty of effectually destroying the potency of a contagium by that means, and to the fallacy of the current popular notions as to disinfection.

† Large rainfalls would have the effect of washing the contagious matter into the water layer, but the contagium thus introduced might not reach the well at the farm for many weeks. I have, therefore, given in the Appendix a rainfall table which Admiral Sir F. W. Grey has courteously permitted me to compile from his Meteorological Register.

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to do with the farm milk. Then we come to case 12, the dairyman's daughter-in-law. Was this really the first case truly belonging to the series having origin in the Brick-kiln Farm milk? or was it due to the use of the farm milk, although not the first care due to it? or was the milk supply here also a coincidence, and the origin of Mrs. W. C.'s illness a thing to be sought for elsewhere? if so, I am at a loss to discover its origin. It does not fall very unnaturally (so far as the intervals between the cases are concerned) into the series of milk cases, supposing the previous cases, Nos. 4, 7, and 8 to have been really cases due to the milk, and also the succeeding cases, Nos. 13 and 14. And if No. 12 was the source from which the contagium reached the farm, it is curious that, considering the free communication between the houses, the first case that followed it (and that possibly presenting another coincidence as to milk supply) did not occur for two months after Mrs. C.'s convalescence. I frankly confess that these coincidences are so numerous, and in their nature so curious, that I am sceptical as to their being all of them mere coincidences.

Summary.

The following are the conclusions which appear to me capable of being drawn from the facts I have been able to gather with respect to the origin and mode of spread of this very remarkable epidemic:—

1. That the chief agent in the distribution of the fever was the supply of milk from Brick-kiln Farm dairy; but that it is highly probable that in some instances local conditions of bad drainage, and pollution of local water supplies, were agents in its extension.
2. That a careful examination of the farm and dairy premises, and observation of the mode in which the business was conducted at the dairy, demonstrated that there were abundant opportunities for the conveyance into the milk of matter of the nature of "filth," and particularly of excremental "filth," and that, under the conditions observed, the introduction of such "filth" into the milk must have been of common occurrence for a long time prior to this inquiry, and prior also to the outbreak of the epidemic.
3. That there were various opportunities for the "filth" thus introduced into the milk, to become specifically infected with the infective matter of enteric fever.

The character of the epidemic in its relation to the milk supply from the farm has been peculiar. The previous milk epidemics investigated either by myself or under the Board's instructions, have been unlike it mainly in this, that they have lasted at the longest only a few months, during which there was a great burst of fever among the dairy customers, which after reaching a climax subsided much in the same way as it commenced, and finally ceased altogether. The peculiarity of the fever prevalence at Ascot has been that it has been protracted, not over a few months merely, but over several years, during all which time the persons attacked have been, with very few exceptions, persons using this farm milk; and that long intervals, sometimes of many months, elapsed between the consecutive cases, the epidemic throughout, however, retaining the same character, and affecting families similarly circumstanced as respects their milk supply. Whatever explanation be adopted, it must be such as will at least adapt itself to this peculiarity of the epidemic. As the fever was fitful and intermittent in its invasions of the several invaded families, so also must the cause or causes of the milk infection have been intermittent, and any or all of the causes suggested as probable lend themselves readily to this condition.

Thus the infection of the water of the well if produced by some cause operating at a distance, such as has been suggested, would probably, considering all the circumstances of the case, be of this character.. The contagium would have had a long distance to travel, would have become diffused probably over a broad extent of subsoil water, and the chances of any of it reaching the particular spot at which the farm is situated would have been few and comparatively of rare occurrence. It is to be remarked that two months elapsed between the first introduction into the ground of the evacuations of the first case at Ascot Wood House (No. 2), and the first case of fever (that at the Hermitage, No. 4) that could be referred with probability to the use of the farm milk, and that over two months elapsed between the occurrence of the case at Keep's Corner and the next case attributable with any probability at all to the use of the farm milk; and that after that case (the second case at Ascot Wood House,

No. 13) no further invasion took place in any family supplied from the farm for nearly three months. This course of events, while it corresponds with what might have been expected had the contagium been derived from a distance, is not at all what might have been looked for had the well infection been derived from a nearer source, such as one of the privies on the farm premises, nor yet with what probably did occur after the farm privy was infected with the excreta of the boy J. C. (No. 33). I confess that I have put forward the suggestion as to this distant source of water infection with much hesitation. I do not consider I have proved that such a thing occurred at all; but I have felt that, in so difficult and unusual a case as this, I was not at liberty to neglect the consideration of anything that occurred to my mind as capable, with even remote probability, of assisting to explain the origin of epidemic.

The issue of infected emanations from the drain into the pump case, or through the kitchen sink pipe, would similarly be intermittent and dependent upon various meteorological conditions, such as variations of atmospheric pressure and temperature which cannot now be traced. In connexion with the operation of this mode of milk pollution, and in support of its probability, at any rate during the latter part of the epidemic, this fact is noteworthy, namely, that on July 10 I caused the drain leading from the kitchen sink and pump to be broken and opened up, thus disconnecting both kitchen and pump from the filthy drain, and the owner of the farm shortly afterwards proceeded at my suggestion to make necessary alterations in view of the possible operation of these and other local causes. A specification of the necessary works was drawn up by Mr. Byrne at my request, and forwarded on July 26th, to the owner of the premises. I have placed this specification in the Appendix to this Report, and it represents what was done and what was left undone. The work was commenced about the middle of August, and on visiting the farm on September 6, I found the greater part of the work completed. The same rags and scrubbing-brush, however, were in use for cleaning, and the same cans. On November 12, new cans were substituted for the old ones, and the use of the rags and scrubbing-brush had been given up. On August 5 a case of fever (No. 64), occurred among the farm customers at Sunninghill in a family not previously invaded; but since that date, although four cases occurred in families, customers of the farm, which had had cases in them previously, I have the authority of Dr. Woodforde for stating that no fresh family has been invaded up to the date of this report. The four cases referred to were readily explicable independently of any question as to milk supply. Having regard to the fact that, on former occasions, intervals of many months had elapsed between consecutive cases of fever, I hesitate for the present to adduce this fact as absolutely decisive of my belief that the improvements made subsequently to July 10 were effectual in removing the causes of the infection of the milk which were in operation towards the close of the epidemic. But the coincidence above mentioned is noteworthy and points in that direction.

May 31, 1878. EDWARD BALLARD.

RECOMMENDATIONS.

The attention of the Sanitary Authority, the Rural Sanitary Authority of Windsor, should be called to the facts related in this Report. Especially they should be requested to consider the danger (demonstrated by this Report) to which the inhabitants are exposed by the use of the well waters for drinking purposes in such districts as Ascot and Sunninghill, where, in consequence of the absence of any systematic provision for carrying away dangerous sewage matters, and disposing of them safely at a distance, these matters soak into the porous sand and inevitably reach the sources of the water supply.

They should be requested to consider whether, in view of the increased and increasing population, the time has not arrived for providing for these places a proper system of sewering and house drainage, and a systematic and constant supply of water from some place sufficiently distant from the population for the avoidance of the risks to which the inhabitants are now exposed.

In the meantime active steps should be taken under the powers conferred on the Sanitary Authority by the Public Health Act, to cause the necessary amendments of the unwholesome privies abounding in these places, for the discovery of the causes of the

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pollution of polluted and unwholesome well waters, and for dealing with such wells in the manner prescribed by the Public Health Act.

The experience of the outbreak of fever to which this report mainly relates, should further have the effect of inducing the Sanitary Authority to pay especial attention to necessary improvements in the several farms and dairies from which milk is sold, both as respects the perfection of their drainage, and the condition of their wells.

The Sanitary Authority should take the necessary steps to provide that all the recommendations made in the specification of works necessary to be carried out at Brick-kiln Farm, with respect to the manure tank and men's privy, and not as yet carried out, be carried into effect forthwith.

APPENDIX A.

SPECIFICATION of WORKS required to be done at Brick Kiln Dairy Farm.

Open up grounds where old drains are shown on plan by yellow and blue lines; break up the old drain pipes; fill in with hard dry rubbish well rammed. Take up the brick catchpool, remove bricks off premises, and fill up with dry brick rubbish. (*Done.*)

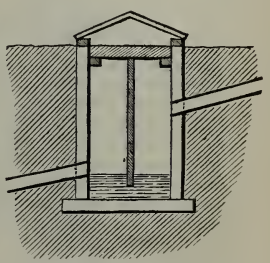
Clean out the present cesspits, cart away soil and bury same in the ground, mixing some slaked stone lime with the soil before burying it. (*Done.*)

Take up the old brick cesspits to the present privies and remove the bricks off the premises, fill up the vacant spaces with dry brick rubbish well mixed with carbolic powder or slaked lime. (*Done.*)

Clear away the manure heap in centre of yard and form a brick in cement tank, say 20 feet by 10 feet by 4 feet deep, the sides raised at least 6 inches above the ground level to prevent surface water from getting in, the bottom of the tank to be laid with 9 inches of concrete composed of one part lias lime to six parts unscreened gravel; ram the earth round walls of tank, and level ground in upper yard with fall towards lower end. (*Instead of carrying out the work as specified, the owner had the manure hole cleaned out, and the sides camp-sheded and boarded and all surface water drains cut off from it.*)

Dig out ground for overflow from small tank near bull's stall, and lay new 4-inch glazed earthenware pipe to proper falls with cement joints to new tank where shown by green line, and cut off and destroy the present defective pipe overflow into ditch from small tank. (*Done.*)

Lay from rain-water pipes and pump sink, where shown by red lines, with 4 inch and 6 inch glazed stoneware pipes cement-jointed, and with all necessary bends, junctions, and connexions with feet of rain-water pipes and brick traps. (*Done.*)



Lay a 6-inch glazed drain pipe from the trap outside the fence where shown on plan to a new brick catchpool in cement 1 foot 6 inches wide 3 feet 6 inches long, and 4 feet deep, with perforated charcoal cover and division slate to form trap as in sketch. Connect this catchpool with a cesspit 5 feet in clear and 6 feet deep for house slops, to be built in cement and domed over on top, form manhole in same, and provide a 2½ inch York cover stone with lift ring leaded in stone, the bottom of cesspit to be concrete as before described, and the sides to be well backed with clay, and the inside rendered in cement. (*The catchpool was not carried up, but a new brick-in cement cesspit as described was formed, with proper wooden cover near ditch.*)

The cesspit to have a 3-inch zinc or iron ventilating pipe carried underground and secured to one of the trees on the side of the ditch close to it. (*Done.*)

Form a hollowed out York stone channel 10 inches by 6 inches from outside the scullery to the grating over trap on outside of fence, or form a three-stone channel in cement to the grating in lieu of the above. (*Done.*)

The sink stone on outside under pump to be fresh tooled and bedded on brick in cement piers. Remove the present lead waste and put a new 1½-inch lead waste to the sink with brass strainer leaded in the waste to empty over a trapped grating under the stone and between the piers. (*Done.*)

Take down the present pump casing, examine and cleanse the sucker and put new leathers, thoroughly cleanse and scrape the small lead cistern over pump rod, refix the pump, and provide an entirely new elm or deal casing to pump. (*Done.*)

The pump to have two new 1½-inch lead water-ways, one into house and one outside, over sinks provided with Lambert's screw-down bibcocks, and 1-inch stopcock to the supply pipe to the copper. (*Done.*)

The inside sink to be retooled, dressed, and reset, the old lead waste removed, and a new lead waste substituted, passing through wall and discharging over the open channel on the outside. The sink to have a 4-inch brass bell trap and grating leaded in. (*Done.*)

Take out the present seat in the privy near house, and provide and fix a proper Moule's earth-closet apparatus, cut out brickwork at side to form doors for drawing out pan; put flush beaded door to this opening in 4 inches by 3 inches rebated frame; the old seat and front may be re-used, but must be planed up; put at back of seat ¾-inch deal beaded matched enclosure for dry earth with sloping inner chamber and cover board. Put 6 inches of concrete under seat and render with Portland cement to form level surface. (*The old privy was taken down and removed altogether and a new earth closet erected on a new site, and properly ventilated.*)

The cesspit to the yard privies being filled up as before described, provide a galvanized iron pail for one closet, the present seats to be cleansed and made to hinge to back frame to remove pans. The second closet to be made into a dry-earth store. (*Not done.*)

Twice limewhite all closets and scullery with lime mixed with some carbolic powder. (*Done.*)

Dig out the ground round the well for a depth of 4 feet, and resteyn well in brick in cement, and puddle the back of the brick in cement with well-tempered clay mixed with chopped straw. (*Done.*)

NOTE.—As soon as the above constructive works are completed (and not before), all the old tins or cans, measures and vessels are to be delivered over, and simultaneously a new supply put in use. (New vessels taken into use, but old ones retained.)

July 26, 1877.

P. J. BYRNE,
Surveyor and Sanitary Inspector,
Windsor.

APPENDIX B.

REPORT on a SAMPLE of WATER received from Dr. Ballard, July 13, 1877.

Sample contained in two Winchester quarts, stoppers tied over with leather and sealed, seals unbroken; each bottle labelled "Critcher's well, July 10, 1877."

The water is clear, but on standing yields a minute trace of deposit; this deposit consists of carbonate of lime chiefly, and is entirely free from animal organisms. The hardness is very moderate, and is due almost entirely to the presence of sulphate of lime. It is free from ammonia, yields only a very small trace of albuminoid ammonia, and absorbs but little oxygen from permanganate. In its present condition it is, therefore, as far as the actual presence of organic impurities is concerned, a very pure water. The water contains however much chlorine, a very large amount of nitric acid, and, comparatively speaking, much phosphoric acid. It also contains a very high proportion of alkali salts. All this indicates that the water has at some period of its history been very largely contaminated by sewage or surface drainage. At present the organic matters thus added have been very completely oxidized, and so far rendered innoxious. But oxidation may not always be so complete as it is at present, and the water would then become entirely unfit for drinking. Even at the best it is not advisable to use such water for drinking.

The analytical details are given in the table annexed.

Appearance	Clear
Colour	Pale greenish yellow
Taste	Tasteless
Smell	Inodorous
Deposit	Very minute trace
Nitrous acid	None
Phosphoric acid	Much
Metallic impurities	None
Hardness before boiling	7·5 degrees
„ after „	5·2 „

Blue..... Old rainwater drains.
Yellow. Old sewage drains.
Red. New rainwater drains.
Green. New sewage drains.

PLAN OF BRICK-KILN FARM.

SHOWING PROPOSED ALTERATIONS TO DRAINAGE.

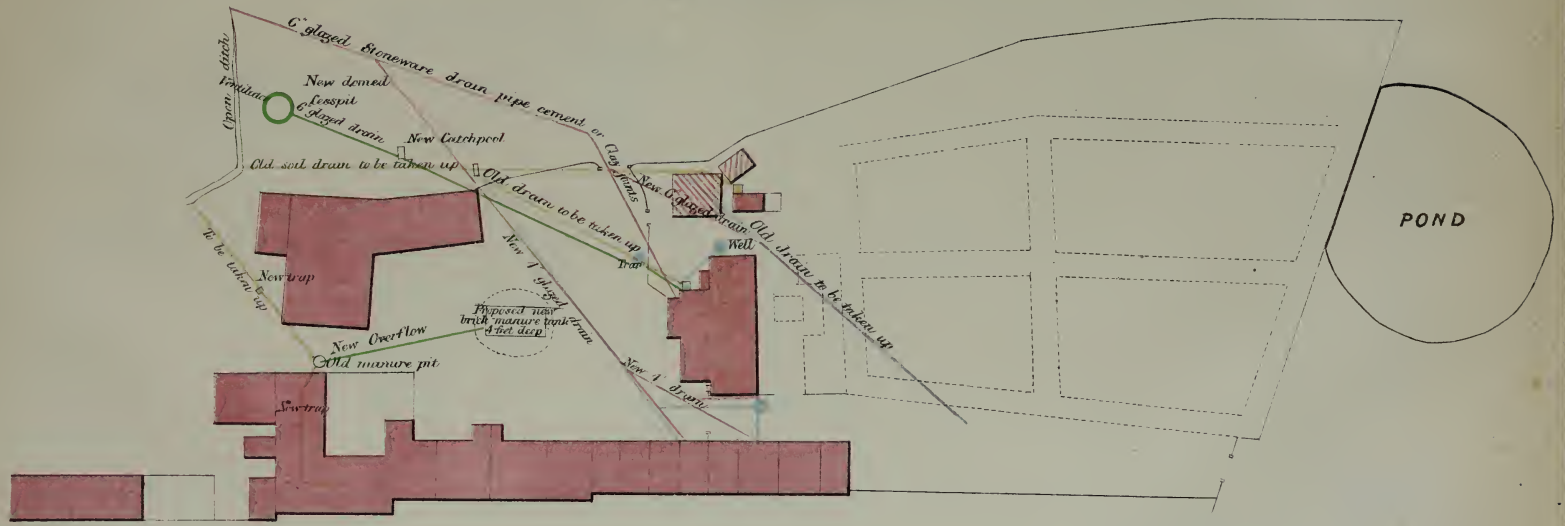
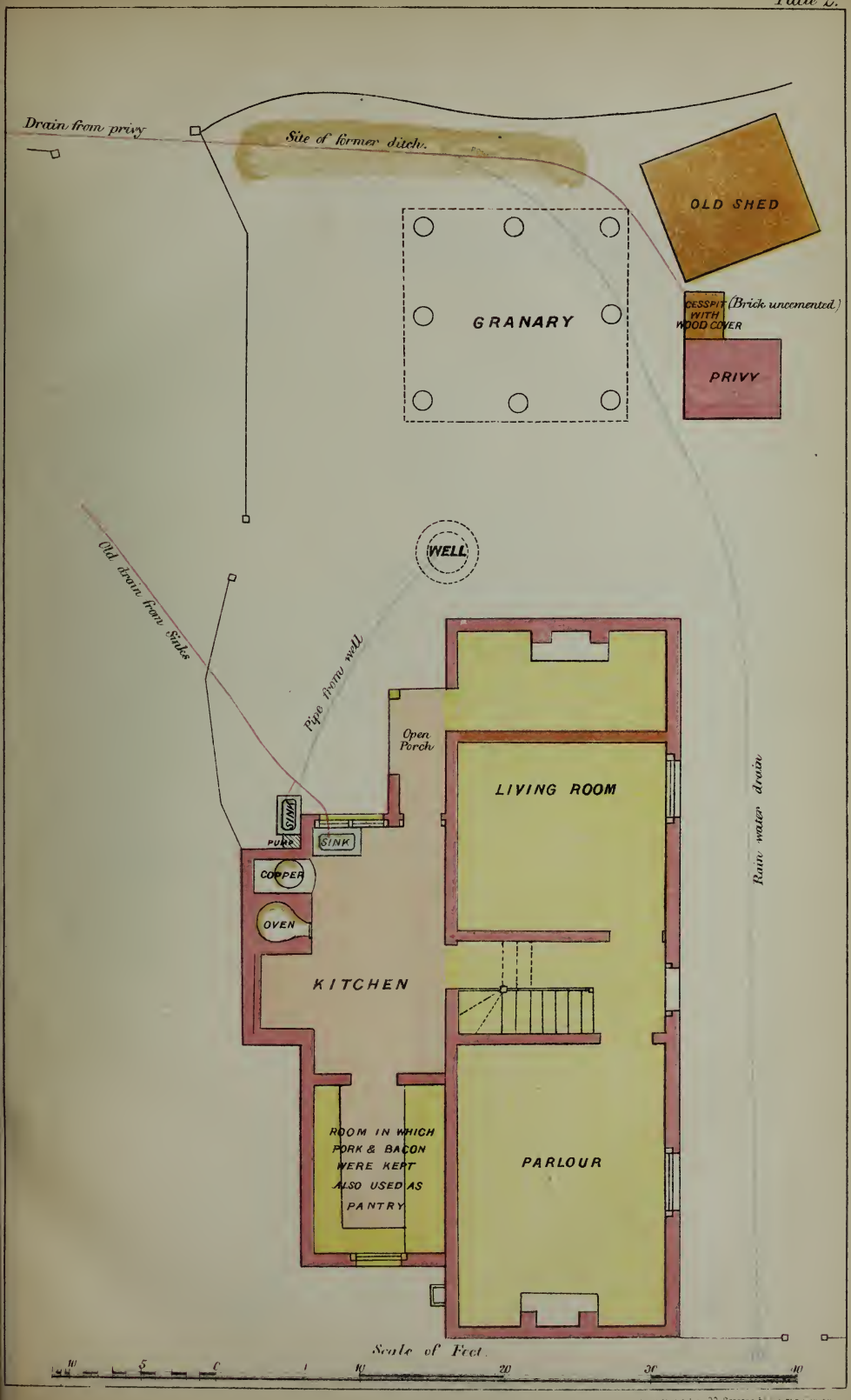


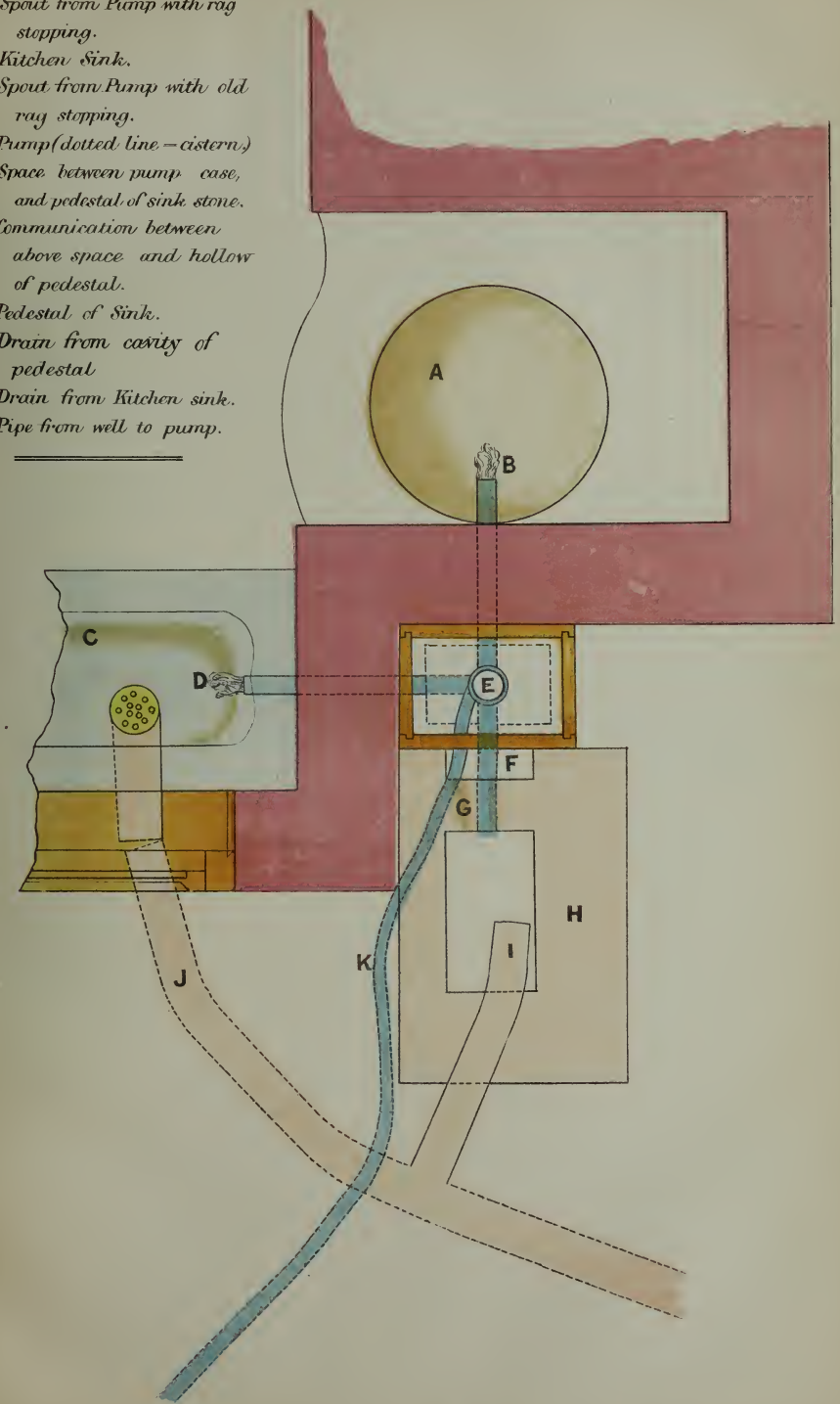
Plate 2.



LANCEFIELD, Lith 22 Bedford St Covent Garden

Plate 3.

A. *Copper.*
B. *Spout from Pump with rag stopping.*
C. *Kitchen Sink.*
D. *Spout from Pump with old rag stopping.*
E. *Pump (dotted line — cistern.)*
F. *Space between pump case, and pedestal of sink stone.*
G. *Communication between above space and hollow of pedestal.*
H. *Pedestal of Sink.*
I. *Drain from cavity of pedestal*
J. *Drain from Kitchen sink.*
K. *Pipe from well to pump.*



Scale of Feet.

12 9 6 3 0 1 2 3 4 5

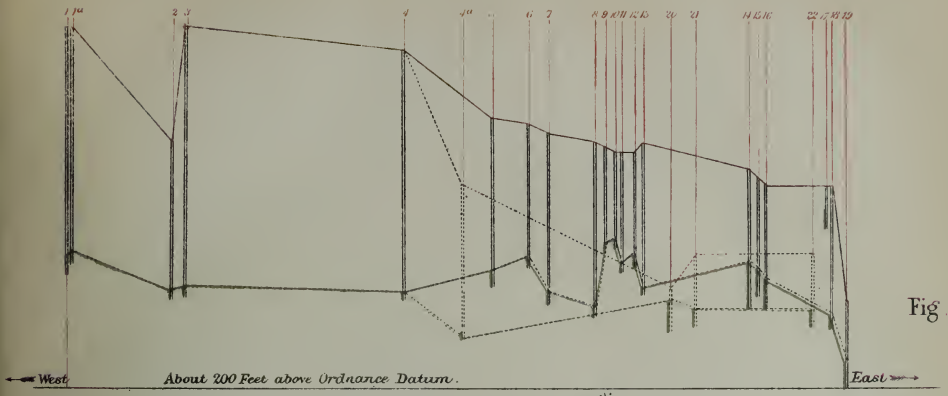


Fig. 1.

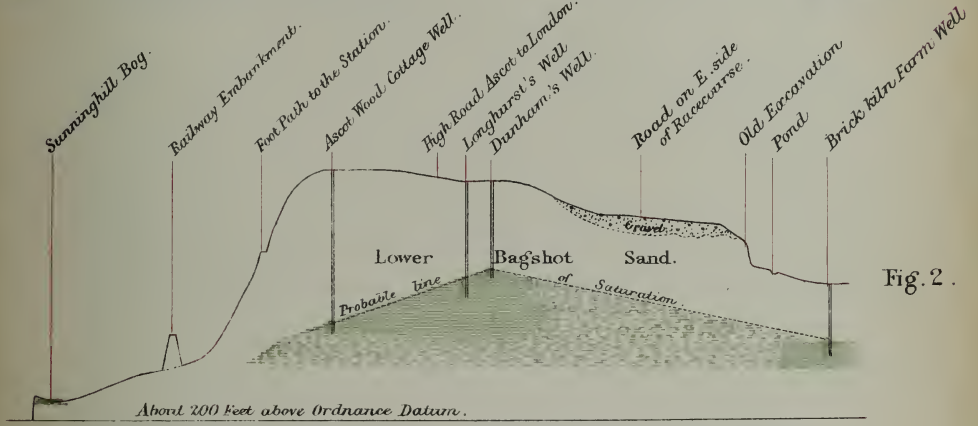


Fig. 2.

Horizontal Scale. *6 Inches to 1 Mile.* Vertical Scale. *1 Inch to 40 Feet.*

EXPLANATION OF DRAWINGS.

Fig 1. *Is an Elevation of the Wells examined at Ascot, the distance of the Wells from one another being given as measured in an East to West direction only, so that the actual distance between the Wells are, of course, not shown. The upper black line simply shows the absolute rise and fall of the surface between one well and another and does not represent a section of the intervening ground.*

The blue line shows the difference of the water-level in the wells. The dotted black line shows the level at the surface of the ground at the wells marked 4, 20, 21, and 22 which are more or less to the north of the other wells. The dotted blue line shows the depth of the water level in the same.*

Fig 2. *Represents a Section in a straight line running from Brick kiln Farm through Ascot Wood Cottage and ending in Sunninghill Bog.*

Both figures are drawn on the same Scale.

C. E. Hawkins.
Geological Survey of Great Britain.

	Grains per gallon.
Oxygen absorbed from permanganate	0·011
Total dry residue	24·01
Consisting of { Volatile matters	7·56
Consisting of { Fixed salts	16·45
Chlorine	3·40
Nitric acid (N^2O^5)	5·18
Ammonia	0·0000
Albuminoid Ammonia	0·0036

A. DUPRÉ.

Westminster Hospital,
July 16, 1877.

APPENDIX C.

TABLE showing the Depths of various Wells at Ascot, the Level of the Water in them approximately, and the Elevation of the Surface of the Ground above Ordnance datum in respect of each.

	Approximate elevation of surface of ground above Ordnance datum, in feet.	Distance from the surface of ground to the water in feet.	Depths of water, in feet.	Total depth of well in water.	Source of information.
1. Well at Ascot hotel	307	70 0	4 0	74 0	Mr. Oades.
1A. Another Do.	307	66 0	4 0	70 0	,,
2. Garden well at "Heatherfield"	272	42 6	3 6	46 0	Owner.
3. House well Do.	307	76 6	3 6	80 0	,,
4. Well at Ascot grand stand	300	71 0	3 0	74 0	
4A. Trial boring on racecourse	260	45 0?	—	—	Mr. Oades.
5. Well at Gothic House	280	44 10	5 2	50 0	
6. ,, ,, Ascot Wood House lodge	278	39 2	2 10	42 0	
7. ,, ,, Ascot Wood cottage	275	46 6	3 8	50 2	
8. ,, ,, ,, ,, house, (new well)	273	49 10	3 2	52 0	
9. ,, ,, New cottage opposite Dunham's, Racecourse Lane.	272	29 0	2 6	31 6	Watson (builder).
10. ,, ,, Dunham's, Racecourse Lane	270	25 0	3 0	28 0	
11. ,, ,, Hermitage (old well)	270	33 2	2 10	36 0	
12. ,, ,, Post Office, Ascot, (Longhurst's)	270	28 5	6 3	34 8	
13. ,, ,, The Hermitage, (new well)	273	43 0	2 6	45 6	Watson (builder).
14. ,, ,, Ashby's, New Mile Lane	265	27 0	14 0	41 0	
15. ,, ,, Holmes' ,,	262	28 0	9 3	37 3	
16. ,, ,, Cowie's ,,	260	27 2	8 10	36 0	
17. ,, ,, The Wilderness, (superficial well)	260	6 0	6 0	12 0	
18. ,, ,, Sunninghill House School, Ascot, (house well.)	260	38 7	4 1	42 8	
19. ,, ,, Sunninghill House School, Ascot, (garden well.)	225	17 6	7 6	25 0	
20. ,, ,, Mr. W. Critcher's, Keep's Corner	230	3 6	9 0	12 6	
21. ,, King's, (between last and Brick-kiln Farm).	240	16 0	5 0	21 0	
22. Brick-kiln Farm	240	16 6	6 0	22 6	

Where the source of information is not stated above, the measurements were made by myself.

In Plate 4, Fig. 1, the red figures correspond to the numbers attached to the several wells in the above Table.

APPENDIX D.

ABSTRACT of RAINFALL REGISTER kept by ADMIRAL SIR FREDERICK WILLIAM GREY, at LYNWOOD, SUNNINGDALE, 1873 to 1877

(Rainfall stated in inches—"Greatest" signifies ·20 and upwards.)

—	1873.		1874.		1875.		1876.		1877.	
	Total.	Greatest.	Total.	Greatest.	Total.	Greatest.	Total.	Greatest.	Total.	Greatest.
January - -	2·80	1st (·56), 9th (·50), 18th (·50).	1·36	3rd (·23), 19th (·30) -	4·06	1st (·51), 15th (·25), 17th (·28), 21st (·47), 23rd (·26), 24th (·57), 29th (·35).	0·99	21st (·37) - -	5·40	2nd (·36), 3rd (·49), 5th (·22), 6th (·44), 7th (·41), 8th (·56), 10th (·63), 14th (·26), 25th (·32), 31st (·40).
February - -	2·14	2nd (·50), 24th (·46), 25th (·54).	1·91	23rd (·23), 26th (·86) -	1·48	5th (·29), 11th (·32), 24th (·46).	2·30	14th (·27), 16th (·21), 20th (·41), 25th (·30), 29th (·29).	1·73	12th (·23), 13th (·35), 19th (·28).
March - - -	2·15	9th (·25), 15th (·28), 16th (·40).	0·47	- - - - - -	0·52	- - - - - -	2·95	1st (·39), 11th (·45), 12th (·39), 27th (·39)	2·61	4th (·21), 7th (·36), 23rd (·32), 24th (·30), 27th (·32), 28th (·30).
April - - -	0·52	- - - - - -	2·01	4th (·78), 9th (·44), 13th (·33).	1·96	6th (·21), 7th (·39), 8th (·74), 21st (·28).	1·97	10th (·31), 12th (·20), 13th (·71).	2·50	5th (·31), 6th (·20), 9th (·37), 20th (·22), 27th (·25).
May - - -	1·54	7th (·49) - -	1·24	22nd (·57), 25th (·30)	1·34	6th (·32), 20th (·21)	0·86	22nd (·24), 24th (·39) -	2·48	12th (·36), 16th (·34), 19th (·47), 31st (·23).
June - - -	1·16	4th (·37), 17th (·22)	3·42	6th (1·74), 16th (·44), 23rd (·38), 26th (·32).	2·70	10th (·58), 12th (·45), 28th (·27).	2·83	2nd (·24), 13th (·58), 15th (·50), 22nd (1·10).	1·15	21st (·75).
July - - -	1·89	5th (·20), 13th (1·27)	1·71	11th (1·0), 27th (·33)	5·35	9th (·41), 10th (·24), 14th (1·54), 15th (1·33), 17th (·29), 18th (·29), 21st (·70).	1·34	8th (·35), 28th (·30), 30th (·26), 31st (·27).	3·57	1st (·27), 5th (·29), 14th (·76), 15th (·44), 16th (·42), 23rd (·67), 25th (·29).
August - . -	1·90	10th (·25), 23rd (·20), 24th (·41).	1·62	13th (·25) - -	0·86	3rd (·27) - - -	2·85	2nd (·21), 4th (·47), 20th (·21), 28th (·37), 30th (·32), 31st (·81).	2·67	7th (·38), 8th (·26), 21st (·53), 25th (·72).
September - -	2·21	7th (·30), 9th (·29), 14th (·71), 15th (·24).	3·03	3rd (·85), 6th (·31), 9th (·43), 10th (·21), 11th (·30), 30th (·51).	1·61	21st (·60), 23rd (·40)	4·30	3rd (·23), 4th (·37), 5th (·22), 7th (·71), 17th (·48), 30th (1·0).	1·26	2nd (·34), 3rd (·43).
October - -	2·66	7th (·22), 11th (·28), 12th (·99), 23rd (·31), 31st (·23).	3·27	1st (·52), 4th (·27), 6th (·30), 7th (·34), 14th (·20), 29th (·48), 30th (·20).	5·30	2nd (·42), 3rd (·28), 14th (·20), 18th (·63), 19th (·89), 20th (·58), 22nd (·90), 23rd (·26), 26th (·27).	1·61	9th (·24), 10th (·27), 12th (·29).	2·40	10th (·20), 22nd (·20), 24th (·45), 25th (·33), 27th (·27), 29th (·41).
November - -	2·10	2nd (·28), 5th (·46), 21st (·20), 26th (·35).	2·99	16th (·42), 28th (·94), 29th (·22), 30th (·74).	3·40	5th (·49), 7th (·42), 9th (·47), 10th (·66), 12th (·36), 13th (·48).	3·50	11th (·35), 12th (·38), 14th (·34), 15th (·25), 18th (·21), 24th (·45), 27th (·60), 30th (·26).	4·64	6th (·43), 11th (1·08), 24th (·83), 26th (·30), 27th (·56).
December - -	0·66	30th (·22) - -	1·71	6th (·20), 8th (·60), 10th (·21).	1·19	5th (·24), 21st (·22)	6·22	1st (·49), 2nd (·31), 3rd (·59), 5th (·40), 7th (·57), 16th (·20), 17th (·27), 19th (·38), 20th (·54), 23rd (·62), 24th (·65), 26th (·29), 29th (·23), 31st (·20).	1·72	5th (·33), 28th (·49).